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UNPUBLISHED PRELIMINARY DATA

National Aeronautics and Space Administration
Washington 25, D.C.

Reference: Contract No. NASr-145

Subject: Quarterly Progress Report Q-B2028-7, covering the period April 22, 1964 to July 21, 1964.

Gentlemen:

The research effort during this report period has been primarily concerned with the dislocation substructure developed in high-purity beryllium during cyclic stressing. A detailed account of these observations is in preparation, and will be presented at the International Conference on Beryllium Metallurgy and Technology, sponsored by AIME, to be held at The Franklin Institute October 15-17,1964. Since the manuscript will be available by September 1, 1964, it is intended that this appear as a supplement to this quarterly report.

(i) Cyclic Stressing and the Deformation Substructure

The dislocation substructure in single crystals of high purity beryllium has been studied after cyclic stressing. Specimen orientations were selected to favor basal or prism slip. The normal to the basal plane was approximately 20° and 45° from the stress axis for the former case. A prism plane was inclined by 45° to the stress axis, for deformation on a prism system, with the stress axis in the basal plane. Fatigue damage in specimens oriented for basal slip was introduced by high frequency reverse bending, and low frequency (~ 2 cpm) cyclic compression. The crystals oriented for prism slip can, if stressed in compression, twin along $\{10\bar{1}2\}$ planes. Therefore, fatigue damage was introduced into these crystals by high frequency simple bending, wherein the stress in one surface was always in tension, and by low frequency cyclic tension.

Silicon monoxide replicas were prepared from the flat surfaces of bend fatigue specimens after the application of a water soluble agent (Victawet 35B) to the beryllium surface by evaporation. After removal from the surface by immersion in distilled water, the replicas were shadowed with tungsten oxide. Slices parallel to the basal, and selected prism planes were cut by spark discharge machining. The sections, which were initially 1 mm in thickness, were thinned by the jet polishing technique to a suitable thickness for examination in the Philips 100B electron microscope.

To the present time, specimens in which fatigue damage occurred by slip on the basal plane have been studied in the greatest detail. Experiments are in progress to examine the case of prism slip. The dislocation substructure associated with fatigue differs from that found after uninterrupted tensile deformation in two respects. First, dislocations are more uniformly distributed in the slip plane after fatigue and there is a relative absence of the dense bundles of dislocations having a large edge component as seen following tensile strain. Second, fatigued specimens contain very large numbers of dislocation loops, approximately 300 Å in diameter. The loops appear to lie in the basal plane. Since loops are not observed to move on the basal plane, and have a component of their Burgers vector out of this plane (diffraction contrast experiments), the loops are sessile in nature. The very large extinction distances in beryllium make it difficult to determine whether or not the loops contain stacking faults. The dislocations are heavily jogged and pinned by the loops, implying that the loops significantly influence the hardening of beryllium.

Large loops up to $\sim$ 2500 Å in diameter, formed during observation in a specimen initially containing high densities of dislocations and smaller loops. Within minutes, loops grew and contracted by climb. Loops of this nature were observed by Berghezan, Fourdeux and Amelinckx in recovered zinc(1), and by Price(2) in cadmium. It is not likely that ion damage in the electron microscope is responsible for this behavior in beryllium. While beryllium does not undergo recovery at room temperature, heating in the beam can be responsible for this observation. After ten minutes the transparent areas of the foil were free of all dislocations and loops. It is intended to use a hot stage to look further into the annealing effect.

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(1) A. Berghezan, A. Fourdeux, S. Amelinckx, Acta Met., 9, (1961), 464.

(2) P. B. Price, Electron Microscopy and Strength of Crystals, p. 41, (1963), Wiley, New York.

(ii) Environment and Fatigue Behavior

In order to study the effect of environment on the fatigue behavior of beryllium, it is necessary to have a thorough understanding of the S-N relationship under normal atmospheric conditions in terms of specimen preparation. Accordingly, polycrystalline torsional fatigue specimens have been prepared from secondary-refined beryllium and are currently under test in air. Having established the 'base-line' S-N curve, it is intended to make a thorough investigation of selected gaseous and liquid environments.

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